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CONTROL OF THE MOUNTAIN PINE BEETLE IN LODGEPOLE PINE BY LETHAL OILS - 1935

By
Archie L. Gibson
Assistant Entomologist

Forest Insect Laboratory
Coeur d'Alene, Idaho
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INTRODUCTION

For a number of years the personnel of the California Station of the Division of Forest Insects have been experimenting with various oils in an effort to control the western pine beetle in western yellow pine. Control is effected by means of a penetrating oil which, with a lethal material in solution, is sprayed on the bole of the tree, where it soaks through the bark and destroys the infesting brood. Varying degrees of success have been secured even on the thicker-barked trees. Believing the oils might be more effective on the thin-barked lodgepole pine, despite growth in an environment of lower maximum temperatures, the California station was requested to allow the Coeur d'Alene personnel to test the more promising solutions on lodgepole pine infested with the mountain pine beetle.

EXPERIMENTS IN LODGEPOLE PINE

In June of 1934 four mountain pine beetle-infested lodgepole pine 11 and 12 inches in diameter, breast high, which had been attacked in 1933 were sprayed to a height of from 20 to 22 feet with oil 21046 R of the Standard Oil Company, which had been supplied to the Coeur d'Alene Laboratory through J. M. Miller of the California Laboratory. These trees were examined on June 30th of the same year and the following conditions observed: Three of the four trees showed high mortality on the sector of the bole of the tree between the northwest, south, and north-

west sides, the area usually exposed to direct sunlight. The sections of the trees exposed to little or no direct sunlight usually showed less mortality and sometimes none was apparent. From examinations of the treated portion of each of the four trees the following data were secured.

STATUS OF THE MOUNTAIN PINE BEETLE IN LODGEPOLE PINE TREATED WITH LETHAL OIL OF FORMULA 21046-R-1934

Tree No.	Dead Brood: Larvae: 0-½	½-1	Pupae	New Adults	Parent Adults	Living Brood: Larvae: 0-½	½-1	Pupae	New Adults	Parent Adults
1	-	35	12	1	-	-	6	7	-	2
2	-	36	8	-	-	-	2	3	1	5
3	-	16	3	-	-	-	10	3	1	-
4	-	12	-	-	1	-	2	-	-	2
	(99	23	1	1	)	(-	20	13	2	9)
			123					35		

Total living and dead brood - - 158
Percent mortality - - - - - - - 78

From the preceding data it is seen that the mortality had been quite high, especially considering that the oil had been on the trees only thirteen days and additional mortality could easily have occurred between the time the trees were examined and the time of emergence. This possibility of further mortality was enhanced by weather conditions favorable to subsequent mortality as evidenced by local high maximum daily temperatures for almost the entire month following the examination.

This small experiment indicated the oil was partially effective and gave promise of giving better control under more favorable conditions, so it was decided to repeat the experiment on a larger scale.

TREATMENTS TO CONTROL THE MOUNTAIN PINE BEETLE

In May and June of 1935 thirty-three mountain pine beetle-infested lodgepole pine near Antelope Flat were sprayed with three different chemicals. On May 29th five of the 33 trees were sprayed with Reilly's Transparent Penetrating Creosote from the Reilly Tar and Chemical Company, using about 2½ gallons. No further spraying was done at that time owing to adverse road conditions making the area almost inaccessible. On June 23rd seven more infested trees were sprayed with the same creosote, using about six gallons; ten with about 8½ gallons of oil 21046-R of the Standard Oil Company; and eleven additional with oil 24241-R from the same source, using about 8½ gallons. The oils were sprayed on the trees to an average height of 17.5 feet, using a Smith-Banner hand pump. To assure thorough soaking the liquid was applied until it dripped from the bark flakes or ran down the crevices.

TREATMENT WITH CREOSOTE

In analyzing the results of treatment, data from the trees sprayed on May 29th and those treated on June 23rd were listed separately in Table 1. It was found that mortality had been much higher in the trees sprayed with creosote in June than those treated in May. It was also noted that the treatment had reduced the living brood in both groups of

trees to where they were fewer than the number which had attacked the tree

Table 1

COMPARISON OF THE MOUNTAIN PINE BEETLE BROOD
IN TREES SPRAYED IN MAY AND IN JUNE WITH
CREOSOTE - ASHTON, IDAHO - 1935

Trees Sprayed in	Brood per square foot at Base: Number Dead	Number Living	Percent Dead	Percent Living	5': Number Dead	Number Living	Percent Dead	Percent Living
May	25.8	4.9	84.0	16.0	27.4	8.6	76.2	23.8
June	40.6	2.5	94.3	5.7	28.6	5.8	83.1	16.9

Examinations of one-quarter square foot of bark surface at the base and at five feet on each of the four sides of the tree supplied the data which are shown in Table 2.

Table 2

DATA FROM TREES SPRAYED WITH KEILLY'S CREOSOTE
ASHTON, IDAHO - 1935

Trees 1-5 Sprayed May 29, 1935 — Data for Basal Section: Attacks per sq.ft.	Females emerging per sq. ft.	Percent emerging females are of attacks	Trees 6-12 Sprayed June 23, 1935 — Data for Basal Section: Attacks per sq. ft.	Females emerging per sq.ft.	Percent emerging females are of attacks
14.7	2.5(1)	17.0	12.7	1.3(1)	10.2
Data for 5' Section			Data for 5' Section		
11.6	4.3(1)	37.1	11.4	2.9(1)	25.4

(1) One-half the total brood comprising both the insects that have emerged and those that are still in the tree at the time of examination.

In both the preceding and succeeding tabulations it has been assumed that each emergence hole represents the emergence of a single beetle. Where, as in these data, the emerging beetles were few and scattered, such an assumption is probably correct, but where the emerging brood is numerous, more than one beetle may use an emergence hole. Considering one half the emerging brood to be females is based on the studies of W. D. Bedard*, who found equal proportions of each sex of the mountain pine beetle at the time of emergence.

An unusual feature of the data was the greater mortality at the base of the tree than at five feet from the ground. In view of the thicker bark at the base, it is natural to expect less mortality there than in the thinner-barked upper portion. However, two factors are believed to have been responsible for this higher death rate in the lower part. After spraying the tree the excess oil drips and seeps toward the base, increasing the period of time and quantity of oil to which that portion is subjected. This is thought to have increased the mortality at the base. The second factor believed to have increased mortality at the base is the presence of sunlight on the basal portion of the tree usually for a longer period than on the more shaded upper portion. Sunlight, because of the higher temperatures it causes, is believed to enhance the effectiveness of the oils, possibly by increasing its penetration. A comparison of mortality on the north side of the trees, which is not exposed to the sun, with the other three sides indicates more control on areas exposed to sunlight.

*W.D.Bedard. New Facts Regarding the Biology of the Mountain Pine Beetle in Western White Pine -- 1931.

Table 3

COMPARISON OF BROOD MORTALITY ON NORTH AND THE OTHER THREE SIDES OF MOUNTAIN PINE BEETLE-INFESTED LODGE-POLE PINE SPRAYED WITH REILLY'S CREOSOTE IN MAY AND JUNE OF 1935 AND EXAMINED IN AUGUST 1935

Data for 12 Trees

Side of Tree	Brood in Basal Section				Brood in 5' Section			
	No. per sq.ft:		Percent		No. per sq.ft:		Percent	
	Dead	Living	Dead	Living	Dead	Living	Dead	Living
N	44.6	9.7	82.2	17.8	28.0	12.0	70.0	30.0
Average of E, S, & W	30.9	1.8	94.5	5.5	27.5	5.5	83.3	16.7

Not only do we learn from the preceding tabulation that the sides of the tree exposed to sunlight showed the best control but in addition less brood had developed on those sides. This was true both at the base of the tree and at the five-foot section.

The effectiveness of control by the treatment just discussed has been pretty well brought out by the preceding tables, but to emphasize this point the brood mortality in the treated trees is compared with that in four nearby untreated trees.

Table 4

COMPARISON OF THE MOUNTAIN PINE BEETLE BROOD IN CREOSOTE-SPRAYED LODGEPOLE AND IN UNTREATED TREES -- ASHTON, IDAHO-1935

Data for 12 treated and 4 untreated trees

	Brood per square foot at							
	Base				5'			
	Number		Percent		Number		Percent	
	Dead	Living	Dead	Living	Dead	Living	Dead	Living
Creosote-treated trees	34.5	3.8	90.0	10.0	27.6	7.2	79.3	20.7
Untreated trees	4.2	24.0	15.0	85.0	4.2	42.0	9.0	91.0

A study of the preceding tabulation shows the surviving brood in the untreated trees to be comparatively heavy, strikingly in contrast to the small amount of survival in the treated trees. Comparing the data for attacks and emergence from the untreated trees in the same manner as is given in Table 2 for the treated trees gives the following figures.

Table 5

DATA FROM FOUR UNTREATED MOUNTAIN PINE BEETLE-INFESTED LODGEPOLE PINE--ASHTON, IDAHO--1935

Data for basal section			Data for 5' section		
Attacks per sq. ft.	Females emerging per sq. ft.	Percent emerging females are of attacking females	Attacks per sq. ft.	Females emerging per sq. ft.	Percent emerging females are of attacking females
16.8	12.0(1)	71.4	13.8	21.0(1)	152.2

(1) One-half the total brood comprising both the insects that have emerged and those that are still in the tree at the time of examination.

A comparison of the data in Table 2 for treated trees and in Table 5 for untreated trees shows that the brood emerging from the former is considerably less than the number that attacked those trees. In the bases of the untreated trees the emergence is less than the number attacking, but at five feet it greatly exceeds the number that attacked.

Variations in bark thickness seem to have had little effect on brood mortality in sprayed trees. Apparently the bark was in no case thick enough to prevent the penetration of the oil. The main control factor seems to have been the oil, whereas sunlight, although apparently increasing the effectiveness of the oil, was but a secondary control factor. It is possible, however, that a heavier application of oil might give even better results than have been secured. An average of 68.5 square feet of bark surface was covered with each gallon of oil. This application was much lighter than any made in western yellow pine by the California Laboratory in their efforts to control the western pine beetle, but the differences may not be so great when volume of bark is considered. The thick bark of the western yellow pine makes it capable of absorbing a much larger quantity of oil per given area than the thin bark of the lodgepole pine. However, if further experiments with this oil are conducted, a heavier application on some trees is suggested.

Brood retardation was noted in the experiments conducted by Hensill* of the Berkeley, California Laboratory on the western pine

*Some Final Field Experiments on Oil Control of Pine Bark Beetles - Season of 1935.

beetle in western yellow pine. Data from this experiment with the mountain pine beetle in lodgepole pine failed to indicate a similar result.

TREATMENT WITH STANDARD OIL FORMULA 21046-R

On June 23, 1935 ten trees were sprayed with about 5½ gallons of Standard Oil Formula 21046-R. The trees averaged 10.5 inches in diameter breast high and were sprayed to an average height of about 19.5 feet. The control secured with this oil was quite good. In the following table the status of the brood on each side of the tree at the base and at five feet above the ground is given.

Table 6

STATUS OF MOUNTAIN PINE BEETLE BROOD IN TEN LODGEPOLE PINE
SPRAYED WITH STANDARD OIL FORMULA 21046-B
ASHTON, IDAHO - 1935

	Data per square foot at Base of tree					5' Above ground				
	Brood			No. of Attacks	Inches of egg gallery	Brood			No. of Attacks	Inches of egg gallery
	Dead	Living	% dead			Dead	Living	% dead		
N	86.0	8.0	91.5	16.0	125.6	101.6	3.6	96.6	8.8	107.6
E	87.6	2.7	97.0	12.9	110.2	54.4	4.4	92.5	11.6	89.2
S	34.7	5.3	86.8	11.1	89.3	49.6	10.8	82.1	14.8	122.0
W	57.2	2.4	96.0	15.6	124.0	61.6	4.0	93.9	9.2	84.8
Average of 4 sides	66.6	4.5	93.7	14.0	112.9	66.8	5.7	92.1	11.1	100.9

From the preceding table it is seen that only on the south side was mortality less than 90 percent, with the average for the four sides nearly 94 percent at the base and slightly over 92 percent at the five-foot section. On this basis better control was secured with this formula than with the creosote. However, comparing results from the two treatments on the basis of number of attacking to emerging insects we find formula 21046-R superior to the treatment with creosote in May, but slightly less effective than the treatment with the same material in late June.

Table 7

COMPARISON OF TEN LODGEPOLE PINE TREATED WITH STANDARD OIL FORMULA 21046-R AND UNTREATED TREES

Pine -- Ashton, Idaho -- 1935

	Data for Basal Sect.			Data for 5' Section		
	Attacks per sq. ft.	Females emerging per sq. ft.	Percent emerging females are of attacks	Attacks per sq. ft.	Females emerging per sq. ft.	Percent emerging females are of attacks
Trees treated with Formula 21046-R	14.0	2.2(1)	15.7	11.1	2.9(1)	26.1
Untreated trees	16.8	12.0(1)	71.4	13.8	21.0(1)	152.2

(1) One-half the total brood comprising both the insects that have emerged and those that are still in the tree at the time of examination.

Similar to the treatment with creosote we find a greater mortality had occurred at the base than at the five-foot section, and again the exposure of the base to an excess of oil running from the higher-sprayed portion above is believed to have caused this higher mortality:

There is not only no evidence that sunlight aided oil 21046-B in controlling the brood but the lower mortality on the south side indicates that it may even have been detrimental.

The excellent control secured with this formula indicates its possible value as a control medium, and further experimentation is suggested. It may be that increasing the quantity of the oil sprayed on the trees will give greater, and possibly complete, control. An average of 57.5 square feet of bark surface was covered with each gallon of this oil.

There was no indication that the treatment had retarded brood development.

TREATMENT WITH STANDARD OIL FORMULA 24241-B

In this experiment eleven mountain pine beetle-infested trees were sprayed with 6½ gallons of oil. The trees averaged twelve inches in diameter, breast high, and were sprayed to an average height of about eighteen feet. The average amount of bark surface covered per gallon of spray was 67 square feet.

In compiling the data from these trees two were found to vary

so strikingly from the other nine in the results attained that they were excluded from consideration.

Control secured from this formula averaged somewhat less than with either of the other two formulae. The trend of the data for the different sides of the tree failed to indicate any effect of sunlight in promoting mortality. The composite data from the nine treated trees and for the untreated trees are presented for comparison in the succeeding table.

Table 8

COMPARISON OF THE MOUNTAIN PINE BEETLE BROOD IN NINE LODGEPOLE PINE SPRAYED WITH STANDARD OIL FORMULA 2A241-R AND IN UNTREATED TREES. ASHTON, IDAHO -- 1935

	Brood per square foot at							
	Base of tree				5' above ground			
	Number		Percent		Number		Percent	
	Dead	Living	Dead	Living	Dead	Living	Dead	Living
Lethal oil treated trees	30.7	9.0	75.6	24.4	34.1	6.9	83.0	17.0
Untreated trees	4.2	24.0	15.0	85.0	4.2	42.0	9.0	91.0

It may be seen that the mortality was quite high from this treatment although somewhat less than with the other two materials. On the basis of living insects which will probably emerge compared with the number attacking the following tabulation is presented.

Table 9

DATA FROM TREES SPRAYED WITH STANDARD OIL FORMULA 24241-R AND FROM FOUR UNTREATED TREES ASHTON, IDAHO -- 1935

	Data for Basal Section			Data for 5' Section		
	Attacks per sq. ft.	Females emerging per sq. ft.	Percent emerging females are of attacking females	Attacks per sq. ft.	Females emerging per sq. ft.	Percent emerging females are of attacking females
Trees treated with 24241-R	14.4	4.5(1)	31.3	13.2	3.5(1)	26.5
Untreated trees	16.8	12.0(1)	71.4	13.8	21.0(1)	152.2

(1) One-half the total brood comprising both the insects that have emerged and those that are still in the tree at the time of examination.

Although this formula was the least effective of the three tried, the females potentially emerging were still less than one-third the estimated number that attacked the tree. However, the better results obtained with the stainless creosote and with formula 21046-R indicate the advisibility of concentrating further experimentation on those two materials and eliminating formula 24241-R from further present consideration. To facilitate comparison of the effectiveness of the three methods Table 10 is presented.

Table 10

COMPARISON OF THE DATA FOR THE THREE TREATMENTS
AND FOR UNTREATED TREES
ASHTON, IDAHO--1935

Treatment	Data for Basal Section: Attacks per sq. ft.	Data for Basal Section: Females emerging per sq. ft. (1)	Data for Basal Section: Percent emerging females are of attacking females	Data for 5' Section: Attacks per sq. ft.	Data for 5' Section: Females emerging per sq. ft. (1)	Data for 5' Section: Percent emerging females are of attacking females
Stainless Creosote						
Trees 1-5	14.7	2.5	17.0	11.6	4.3	37.1
Trees 6-12	12.7	1.3	10.2	11.4	2.9	25.4
Average of Trees 1-12	13.6	1.9	14.0	11.5	3.6	31.3
Formula 21046-B	14.0	2.2	15.7	11.1	2.9	26.1
Formula 24241-B	14.4	4.5	31.3	13.2	3.5	26.5
Untreated	16.8	12.0	71.4	13.6	21.0	152.2

(1) One-half the total brood comprising both the insects that have emerged and those that are still in the tree at the time of examination.

In the preceding table it may be seen that an average of the percent of emerging females for all trees treated with stainless creosote would be slightly higher than that secured with formula 21046-R. Considering only trees 6 to 12, treated in late June, stainless creosote gave slightly better control than formula 21046-R. On the latter basis, however, there is very little to choose between the effectiveness of the two materials. Control for the two sections of the trees examined indicates formula 24241-R is the least effective of the three methods tried, but a comparison of effectiveness of control at the five-foot section for the late-sprayed, creosote-treated trees and the other two methods leaves very little choice between the three.

If we judge the effectiveness of the treatments by the number of insects emerging per square foot, the late spraying with creosote gave slightly better results than Formula 21046-R, and Formula 24241-R was least effective.

In future experimentation it is hoped the stainless creosote and Formula 21046-R can be given further tests both undiluted and in mixture with the materials the California Laboratory found to be most effective.

SUMMARY

The more important observations made in these experiments were that:

1. Spraying mountain pine beetle-infested trees with Reilly's Stainless Penetrating Creosote late in June gave better control

than when sprayed in early May.

2. Sunlight on the sprayed area of trees treated with the creosote seems to increase the mortality of the infesting brood.

3. Trees sprayed with Standard Oil Formula 21046-R gave almost as good control as the trees sprayed with creosote in late June.

4. Trees sprayed with Standard Oil Formula 24241-R gave the least control of the three materials used.

5. A heavier spraying with the creosote may increase its effectiveness.

6. All three materials reduced the potentially emerging brood to less than half the number that attacked the sprayed area.

7. Differences in bark thickness in lodgepole pine apparently had little effect on the mortality secured by spraying.

8. There were no indications that brood development had been retarded by any of the spray materials.